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NASAT_EX: a Document Preparation System

Arthur Ogawa

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PREFACE

This manual documents the TEX-based publishing system developed under contract to the STEPS project at NASA Ames Research Center for its scientific and technical writers. The system is called NASATEXand represents a way of using the TEX typesetting system to its fullest advantage in technical publishing. The goal of this effort is to facilitate the work of authors all over the NASA Ames sites in preparing all their technical publications, and to facilitate the work of the manuscript preparation, illustration, and editorial staff in preparing such documents for final publication.

The system emphasizes the advantages of descriptive markup: authors need not be primarily concerned with the actual format of their documents and will use the same markup system no matter what the publication may be, TP, TM, AIAA conference paper, etc. The use of descriptive markup also reduces the total number of commands that one needs to learn to write one's documents, so the system is easy to learn.

In addition, the system provides for a high level of graphics integration: when the illustrations of a document are computer generated, they are incorporated into the production cycle in a way that ensures convenience and fidelity.

QUICKSTART

If you already have NASATEX installed on your computer system and are already familiar with LaTEX, you may want to start immediately by reading the chapter "If you already know LaTEX" and then formatting one of the example files, comparing the formatted output with the document's markup. Consult your local guide for instructions on how to invoke TEX under the NASATEX macro package, and where to find the example files. You will also want to refer to the section "Working With Graphics" to learn how to integrate your computer-generated art into your text.

INSTALLATION AND LOCAL GUIDE

Instructions on the installation of NASATEX on your system are contained in a separate installation manual. Running NASATEX will vary from one system to another, so there is a separate local guide to NASATEX for your system. If necessary, see the section "Whom to Turn to for Help" at the end of this preface.

COMPUTER SAVVY AND TEX AWARENESS

In explaining how to use the system, I assume that you are familiar with the computational environment you are working with, that you know how to create and modify documents (or files), that you are aware of the pitfalls of your system, that you know how to maintain your information, and so on. I also assume you have some familiarity with TEX and LaTEX, although not more than you would learn in a introductory training session.

HOW TO USE THIS DOCUMENT

The manual consists of a User's Guide, a Tutorial, a User's Reference, and a Technical Reference.

The User's Guide will help you learn how to use NASATEX even if you have not used TEX or LaTEX very much in the past. It will help you orient yourself by taking you on a guided tour through the preparation of a document, from markup to camera-ready copy. A special chapter in the user's guide, "If you already know LaTEX," is for those whose depth of familiarity with LaTEX enables them to learn NASATEX using LaTEX as a starting point.

The Tutorial is to help you learn by example. Each of several different elements is treated from basic to complex usage. By completing each of the Tutorial units, you will learn how to prepare even the most complex documents.

The User's Reference manual contains formal references for each of the commands in NASATEX. You will probably use this part of the manual to obtain a clearer grasp of all the different ways a command may be used. When you are introduced to a command for the first time, either in the User's Guide or the Tutorial, I deliberately will not attempt to give an exhaustive explanation; however, when you return to a command having used it already, you will want to refer to the discussion in the User's Reference.

Finally, the Technical Reference is for those who wish to look behind the scenes. It is a guide to how the system was implemented and will aid you if you wish to extend the system to new document styles or to fix problems. You must have fairly advanced TeX programming skills to alter NASATeX.

WHOM TO TURN TO FOR HELP

If you need help in obtaining the related software or need training in TeX and LaTeX, please contact the TeX liason, Rachelle Stevenson, at Central Computing Services. If you require help in using an already-existing installation, you should contact your local system administrator. If you have a personal computer or a workstation not connected to a file server, you should contact the site coordinator for the system you are using.

CONTENTS

PART ONE

USERS GUIDE TO NASATEX

CHAPTER 1

INTRODUCTION

This guide gives you an introduction to NASATEX and shows you how to use the system to create and format your documents. If this is your first exposure to NASATEX, you will probably want to use this guide in conjunction with the Tutorial and the Users Reference. Working through the examples in the Tutorial will give you valuable hands-on experience in the most useful commands in the system; you may consolidate your understanding by using the Users Reference for a more thorough and formal description of the commands and concepts.

1.1 WHAT NASATEX IS

In brief, NASATEX is a macro package built on top of the LaTeX document preparation system; it formats documents according to the specifications of NASA Ames, and of the publications that NASA authors commonly submit their papers to. LaTeX itself is a macro package built on top of the TEX typesetting system (or formatting engine ... NASATEX inherits all of the strengths of T... . In addition, support for the special ... TEX is part of the system, ... math typesetting possibil-

... engine

... tting system in the ... spectrum of com- ... large selection of ... It was devel- ... Knuth and is ... nctive in sev- ... inely typeset ... raphy), par- ti... n and jus- tifi... oxes and glue ... complex of la... or math typeset- ting. ... programming facility and parsing ... wing one to create a system of high-lev... ptive markup for the input documents (that is, a macro package).

TEX is typically used as a batch processor. You create an electronic document with your text interspersed with markup, or commands, in TEX's language. TEX reads the document, recognizing and executing your embedded commands and producing an output document, the device-independent DVI file. The DVI file is usually translated by yet another program to the device-specific language of your printer, whereupon you obtain hardcopy output of the formatted material. Some implementations of TEX also provide a screen preview of your typeset output.

1.1.2 Descriptive markup

LaTeX is a set of procedures written in TEX's programming language; it establishes a uniform syntax for markup. LaTeX's commands have the important aspect that they are descriptive rather than procedural in nature. For instance, instead of embedding perhaps dozens of commands to format a level-one head, you just type `\section{What \NASATeX\ does for you}`. That is, you indicate the structure of your document by giving the `\section` command, rather than instructing TEX to carry out a sequence of commands that might result in the same formatted output, but that do not indicate at all the fact that you started a new section.

Many authors at NASA use TEX to prepare their scientific and technical papers because it provides the most convenient way of making sure that the complex mathematical expressions in their papers are set accurately and cleanly. Authors may use various macro packages; some use LaTeX, others have developed their own.

To support NASA's authors, the members of STEPS created in NASATEX a completely descriptive system of markup, carrying on the original intent of LaTeX. NASATEX additionally supports the special documents elements commonly found in NASA publications and the various document formats that NASA authors are required to follow. So preparing a publication with NASATEX is significantly easier than using Plain TEX, or a narrowly focussed LaTeX document style.

1.1.3 Format independence

Descriptive markup has the advantage that when two different authors prepare papers for two different publications, they will use identical markup for their documents. This means that a technical typist supporting the two authors need only learn one system of markup, no matter how different the formatting of the two target publications may be.

In fact, an author may prepare a document for simultaneous release as a NASA TP and, say, an AIAA journal article. The same electronic source document is formatted twice with only a small change in a command at the beginning of the file, resulting, on the one hand, in a double-column single-spaced document with figures and tables in place in the text, and on the other hand, in a single-column double-spaced document with figures and tables collected at the end, as is required for a journal typescript.

1.2 HOW TO USE NASATEX

If you are already using TEX on your computer, you will have no trouble using the NASATEX macro package. You will have to obtain a release of the NASATEX files for your particular computer and printer. Then simply prepare a document using the markup commands in this guide, or use one of the example files in the NASATEX release. Next, typeset your file with the `NASATeX` command file or batch file provided with your release. (If you are using a Macintosh, you typeset your file in OzTEX or TEXtures after having specified the NASATeX format as the format of choice following the instructions for the respective program.) Finally, preview and print your DVI file as usual.

CHAPTER 2

BASIC INFORMATION ABOUT TEX AND LATEX

Since NASATEX was meant to be used by people with a wide variety of experience, courses are periodically given to provide basic skills and training. If you have not yet taken such a course, you should contact the people in charge of training (mentioned in the Preface).

The material in the first two chapters of Lamport's LATEX*: A Document Preparation System* is indispensable. In addition, Chapter 3's discussion of math typing is necessary for anyone who want to set math into type. If you want to substitute book study for a training course, you should study these chapters carefully.

For those who already have experience with TEX and LATEX, I summarize the essential concepts here:

file name When you create your document, you must give it a file name whose extension is `.tex`. LATEX creates auxiliary files whose names are derived from the file name of the document that it formats. If your document's name does not conform, the names of the auxiliary files may not be correct.

Some systems are case-insensitive, so even if yours is not, refrain from naming files in such a way that there would be a name collision under such a system. In addition, the colon (:), the brackets ([and]), and both slashes (/ and \) are among those characters used to indicate directory structure in various operating systems. For greatest portability, refrain from using these characters in your filenames, even if your system allows it.

Some operating systems (for instance Macintosh) allow you to name your files using embedded spaces and special characters, such as accented characters and punctuation. All of the files connected with TEX, including placed graphics files, must have names that TEX is capable of employing, so for best results (and for greatest portability), restrict filenames to the alphabetic characters plus the priod character, using no more than eight characters before the period, and no more than three characters after.

character set Versions TEX2.xxx and earlier are restricted to the visible ASCII characters, while TEX3 and later will accept all 8-bit codes. Note that if you use 8-bit characters in your document, you must take care when moving your files between dissimilar operating systems to transport your files in image (or binary) mode.

Certain characters are special escape characters for TEX. They are

```
# $ % & ~ _ ^ \ { }
```

and are used only in TEX commands. Additionally, three characters are commonly used by LATEX in its commands:

```
* [ ]
```

You should be wary when using these characters in your file, since LATEX may consider them to be a part of a command.

white space and blank lines TEX treats any number of consecutive blanks and tabs as a single space. The endline character is also treated as space in this sense. However, one or more completely blank lines signifies the end of a paragraph (`\par`). The command \par will produce errors or erroneous formatting in certain contexts, so the conservative rule is to put a blank line into your file only if the next line begins a new paragraph and that paragraph is to be indented.

quotation marks Always use directional quotes, namely ‘ and ’, which you may double up for directional double quotes; never use the nondirectional double quote, ", for quotations.

hyphen, en-dash, em-dash, and minus The hyphen character (-) itself is used in a context like "Navier-Stokes equation" or "X-Y plane." The en-dash is produced by typing two hypens (--) and is used for a range of values, like "A–Z." The em-dash is produced by typing three hyphens (---) and is used to create a major break in a sentence—like in this sentence. The minus sign is obtained when you type the hyphen character in math mode. Never put white space space or a line-end before or after the hyphen, en-dash, or em-dash.

space at end of sentence Punctuation like a period (.), a question mark (?), and an exclamation point (!) usually signify the end of a sentence, so TeX sets a special amount of space in such places (usually a bit more space than between words). If any of these punctuation marks doesn't really end the sentence (e.g., after an abbreviation like "etc."), you must replace the space character following the punctuation by the command \␣ (backslash-space).

Such punctuation also may occur immediately following an uppercase letter. Because this often happens in places where the punctuation doesn't end the sentence (e.g., an author initial in a bibliography), TeX is programmed to set ordinary word space there. If the sentence really does end there, you must precede the punctuation with the command `\@`.

non-breaking space The tie character (~)—actually a TeX command—is used to supply space without allowing a linebreak, as in the case of `the line~A` or `\(x\)~axis`. Get in the habit of typing the tie in every such instance, not just in those where you actually see a bad break.

Obtaining the escape characters You may set the actual letters corresponding to TeX's escape characters by typing, e.g., `\$ \& \% # ^ _ { }`.

typing TeX's commands TeX's commands consist of the backslash character followed by either a single non-letter (like `\@`) or by one or more letters (like `\LaTeX`). The latter type of command is known as a multiletter control sequence name. The only way for TeX to know when a multiletter command ends is when it sees a non-letter, so if you if you want to set a word like "the TeXbook", you type `the \TeX book`. In this case, it is an error to type `the \TeXbook` because you are effectively invoking the (undefined) command `\TeXbook`.

If you want to set a phrase like "TeX command", you type `\TeX\ command`. Note that in order to set a space immediately following a multiletter command, you must use the \␣ command.

Some commands expect to see arguments following them; usually you type a command's arguments within braces immediately following a command.

LaTeX commands LaTeX's commands are the same as TeX's, but there are differences in what follows the command. In LaTeX, commands are optionally followed by a star `*` to indicate variant processing. Some commands take an optional argument enclosed within brackets (`[]`); this will precede any of the command's usual (required) arguments.

LaTeX has an additional command syntax called an **environment**. To use it, you identify a range of your document to be processed under the **scope** of the environment, and suitably mark both its beginning and end, e.g.,

```
\begin{quotation}%
Here is the text of my quotation
\end{quotation}
```

Note that the environment name is present at both beginning and end of the environment; this provides for a degree of error-checking.

An environment may itself have a starred variant; this is indicated by adding a `*` to the name of the environment, as in

```
\begin{quotation*}
Here is the text of my quotation
\end{quotation*}
```

An environment may also take arguments, even optional arguments; you type these immediately following the `\begin{`*environment*`}` command.

comments When TeX encounters the `%` character in its input, it ignores it and all remaining characters in that line, including the space that the line-end would have created. You may introduce comments into your file in this way, or you may use the comment character to end a line without producing space. A TeX command name or LaTeX environment name must not be interrupted by a comment, however.

math mode LaTeX has several different ways of marking math expressions. The syntax of Plain TeX, using the `$` character, does work, but is not recommended. Use the marks `\(` and `\)` instead; this will facilitate the use of syntax checkers to verify the integrity of your file.

Display math may be set off with the `\[` and `\]` commands; a better choice is to use the `{equation*}` environment to obtain an unnumbered display math equation.

Note that all spaces are ignored in math mode, that subscripts and superscripts are marked with the characters `_` and `^`, respectively, and that you may set type in the body font by using the `\mbox` command.

CHAPTER 3

IF YOU ALREADY KNOW LaTeX

This chapter describes how to proceed if you are already familiar with the LaTeX document formatting system. I describe the most important differences between the article style of LaTeX and NASATeX, and refer to the relevant sections of the User Reference for more complete information.

Since NASATeX is very similar to LaTeX's article style, you will find yourself in a familiar environment. NASATeX, however, provides significant extensions to LaTeX's descriptive markup scheme—it is even more descriptive. Therefore, you will find descriptive markup for structures that you formerly did in a more procedural way with LaTeX. It is important that you always use the most descriptive tool for the job—even if you work out an alternate but more procedural way to accomplish the same task, it will be less easily maintained if, for instance, your document is resubmitted to a different publisher.

3.1 OVERALL DOCUMENT STRUCTURE

NASATeX shares LaTeX's approach to document structure by having a *preamble* followed by *document content*, with the latter set off by `\begin{document}` and `\end{document}` statements. Your overall document structure will then be

preamble
`\begin{document}`
document content
`\end{document}`

NASATeX shares LaTeX's `\include` and `\includeonly` commands, and supports a `*` variant for the `\include` command, indicating that `\includeonly` statement notwithstanding, the document portion is *not* to be processed. You may have any number of `\includeonly` statements; NASATeX processes *any* file mentioned in any of the `\includeonly` statements.

Finally, you may give the preamble command `\includeall`, which overrides the `\includeonly` statements and the effect of the `\include*` commands, forcing TeX to process all of the `\include`d files and eschewing the pagebreak that the `\include` command usually forces.

See the section "Partial Processing" in the User Reference for more details on the `\include` commands.

3.1.1 Document Style

NASATeX comes with almost all of LaTeX's article style preloaded. Beyond this, you will choose a document style and document style options based on the particular target publication. For instance, if you wish your document formatted as a NASA Technical Publication, you will select the NASA document style and the TP document style option:

```
\documentstyle[TP]{NASA}
```

Or, if you will be submitting your document as a conference paper to the AIAA, you would use

```
\documentstyle[conference]{AIAA}
```

NASATeX also includes a formatting style for American Helicopter Society conference papers and preprints. Formatting options for more target publications are under development; see the section "Document Styles" in the User Reference for a complete list of target publications and related options.

3.1.2 Title, Author, and Other Data

LaTeX's mechanism for specifying the title, author, and other data in the document preamble has been enhanced to address the complex needs of NASA's authors. The `\title` command is unchanged, but a `\subtitle` command has been added for use where appropriate. There are commands to specify the copyright date (`\copydate`), the publication date (`\pubdate`), the publication number (`\pubnumber`), and the journal to which the document has been submitted (`\submitted`).

The author is specified in the usual way

`\author{`*name*`\and `*name*`\and `*name*`}%`

but the *name* has been enhanced to include the author's affiliation and title, where needed:

`\author{%`
 name`%`
 `\affiliation{`*institution*`}%`
 `\authortitle{`*title*`}%`
`}%`

See the section "Preamble Commands" in the User Reference for complete details on these extensions.

3.1.3 Front matter

LaTeX's scheme has no way to divide the *document content* into front matter and body; NASATeX introduces the frontmatter environment to do so. The recommended front matter is:

```
\begin{frontmatter}%
\maketitle
\tableofcontents
\end{frontmatter}%
```

You may also wish to include the \listoffigures and \listoftables commands after the \tableofcontents command.

3.1.4 Sectioning

LaTeX's usual set of sectioning commands, \part, \chapter, \section, \paragraph, etc., have been supplemented with environments for structures that commonly appear in NASA's technical documents. These are Summary, nomenclature, and Conclusion.

The Summary environment contains a synopsis of the document and is used where an abstract is called for. If the document's summary is to be formatted as part of the title page, the Summary environment must appear in the preamble, where it can communicate properly with the \maketitle command. Type the Summary environment as follows:

```
\begin{Summary}
This paper describes recent advances
in calculating closed-form solutions
to the nonlinear Schr\"odinger equation.
\end{Summary}
```

The nomenclature environment is for explaining the mathematical terms used in your document. It presents a two-column tabular-like environment that can break over pages. The left column is in math mode, the right is a paragraph.

```
\begin{nomenclature}
term&meaning\\
term&meaning
\end{nomenclature}
```

Note that the * form of the nomenclature environment is used in conjunction with the equation or eqnarray environment to provide for the common "where..." construct; see the section "Math," below.

The Conclusion environment will contain the conclusions for your document (and will be followed automatically by the terminal ending if your document is a NASA Technical Paper).

NASATeX follows LaTeX's way of delineating the appendix, by means of the \appendix command. It provides for the special case of a single appendix with the * form of this same command; i.e., \appendix*. Thus, if your document has appendices, type

```
\chapter{A Chapter}
\chapter{Another Chapter}
\appendix
\chapter{An Appendix}%
\chapter{Another Appendix}%
```

However, if your document has exactly one appendix, type

```
\chapter{A Chapter}
\chapter{Another Chapter}
\appendix*
\chapter{A Single Appendix}%
```

For more details on NASATeX's extensions to LaTeX's sectioning commands, see the section "Sectioning" in the User Reference.

3.1.5 Synopsis

The overall structure of a typical document can be summarized by the following example:

```
\documentstyle[TP]{NASA}%
\title{%
 Effect of Surface Catalysis on Heating
 }%
\author{%
 David A. Stewart\authortitle{Research Scientist}%
  \affiliation{NASA Ames Research Center}%
 }%
\begin{document}
%
\begin{frontmatter}%
\maketitle
\tableofcontents
\end{frontmatter}%
%
\begin{Summary}
```

```
Several reports have been written on
the performance of the Quiet Aircraft
\end{Summary}
%
\section{Introduction}
The Quiet Short-Haul Research Aircraft
(QSRA) is one of the many aircraft.
%
\begin{Conclusion}%
The downwash angle increases
with increasing USB flap setting.
\end{Conclusion}%
%
\appendix*
\section{Downwash characteristics}
Important information gained during this test
\begin{thebibliography}%
%
\bibitem[Eppel\year{1981}]{Eppel}%
Eppel, J.C.:  Quiet Short-Haul Research Aircraft
\end{thebibliography}%
%
\end{document}
```

For a more detailed example of a NASATEX document, examine the file Example.tex in your NASATEX distribution.

3.2 MATH

NASATEX cleaves to LaTEX's a way of marking math formulas. The recommended way of marking an in-line math formula is with the \(and \) commands, rather than with TEX's $ escape. This notation allows automatic checking of math formulas to be sure they are properly closed. Both emacs (on Unix and DOS) and QUED/M (on Macintosh) provide a facility for checking proper balancing of the delimiters used in LaTEX files. See the section "Balancing Delimiters" in the User Reference.

Your display math formulas should appear within equation or eqnarray environments, which will automatically apply an equation number. If you have an exceptional equation that is not to be numbered, you may use NASATEX's * form of these environments—the equation number will be suppressed. Thus, you can type

```
\begin{equation*}%
Your math expression here
\end{equation*}%
```

for an unnumbered equation.

NASATEX also provides a subeqnarray environment for those cases in which an equation is presented in parts:

```
\begin{subeqnarray}%
this line will be labeled, e.g., 1a\\
and this line will be labeled 1b\\
and this line will be labeled 1c\\
\end{subeqnarray}%
```

NASATEX has a simple way of obtaining certain math symbols in boldface: use the \bf font switch. For instance, you can type

```
\begin{equation}%
R_{\theta_e}=
 {R_{\theta_s}+R_{\theta_e}
  \over\bf R_{\theta_s}+R_{\theta_e}
  }
\end{equation}%
```

if you want to obtain

$$R_{\theta_e} = \frac{R_{\theta_s} + R_{\theta_e}}{\mathbf{R}_{\ s} + \mathbf{R}_{\ e}} \tag{3.1}$$

Note that the \bf font switch applies to Roman and Greek letters only, not math delimiters and relations.

See the section "Math" in the User Reference for more information on commands for math markup.

3.3 LISTS

NASATEX provides for the same kinds of lists that LaTEX does; they are enumerate, itemize, and decription. As with LaTEX, such lists may be nested.

3.4 FIGURES AND TABLES

The NASATEX package distinguishes a figure or table, which is generally numbered and has a caption, from the material that is actually placed therein, like artwork or an alignment (tabular material). In NASATEX, figures and tables are provided with considerably more structure than in LaTEX, in that a Figure or Table always has a *caption* argument and a *key* argument. A Figure or Table may therefore contain only one *caption* (subcaptions are provided for separately). A figure is marked up as follows:

```
\begin{Figure}{caption}{key}
content
\end{Figure}
```

The *key* argument is effectively used as the argument of a \label command. If you do not wish to specify a *key* for your figure (e.g., it is never referred to), you must still supply a pair of braces ({}) as a placeholder for this argument. Similarly, if for some unusual reason you wish your figure to have no caption, you must still supply a pair of braces ({}) as a placeholder for the caption.

LaTeX's usual mechanism for supplying an optional placement parameter, consisting of any choice of the letters htbp is applicable to the Figure environment, as is the * modifier signifying that the figure is to span the full page width of a two-column layout. NASATeX also provides for an optional caption (to be set in the list of figures) and a * modifier signifying that the figure is to be unnumbered. One caveat: if you specify the optional caption, you must explicitly specify the placement parameter, in order to avoid ambiguity. A sample Figure environment using all these options is:

```
\begin{Figure*}[hbt]
*[optional caption]{required caption}
{key}
content
\end{Figure*}
```

The Table environment is entirely analogous to the Figure environment. For more details on these environments, including figure subcaptions and table footnotes, see the section "Figures and Tables" in the User Reference.

3.5 ART

Publishers refer to photographs and diagrams appearing in a book or article as "art". Usually art will appear as the content of a Figure environment. LaTeX provides for art using the picture environment. NASATeX provides for two types of art: traditional, manually placed art (manual art) and electronically generated and placed art (electronic art). In some installations of NASATeX, the picture environment is not a part of the base format file and must be incorporated explicitly. To do so, place a \documentstyle{picture} command in your document's preamble.

Rather than use the picture environment, the Technical Information Division (TID) encourages authors to generate their art either manually or via Visual Information Specialists according to NASA guidelines. The preferred vehicle for electronic art is the Adobe Illustrator format of Encapsulated PostScript file.

The NASATeX command for placing manual art is the \dropArt command, which allows you to specify the width and height of your manual art, and to specify a text string identifying the art:

```
\dropArt(width,height,0){identifier}%
```

TeX will print the identifier within a ruled box—a placeholder—of the specified dimensions (in units of \unitlength) in lieu of the actual image, which will be pasted onto the camera-ready copy by hand at TID.

Electronic art is placed with the \dropeps command, which allows you to specify optionally the size of the art, its magnification, and whether to scale to fit available space:

\dropeps{*filename*} places the file specified by *filename* at unity scale

\dropeps(*scale*){*filename*} places *filename* at the specified scale (1.0=100%). If the specified scale is nil, it assumes unity scale.

\dropeps*{*filename*} places *filename* scaled to the current \hsize and \textheight

\dropeps*(*width*,*height*,0){*filename*} places *filename* scaled to fit within the specified box

where the dimensions are specified in terms of \unitlength.

Document style options guide and insert govern the processing of graphics. The insert option determines whether the graphic image will actually be shown on the page. If not, TeX simply leaves a blank area of the correct size. The guide option governs the appearance of a ruled box the size of the graphic to be placed. This option is useful in pasteup and for debugging.

For more details on art placement, see the section "Art" in the User Reference.

3.6 ALIGNMENTS

The usual content of a Table is tabular material, or alignment. The LaTeX tabular environment has been equipped with some additional commands making alignments more descriptive and, therefore, more standardized. There are standard rules to appear above and below an alignment—\toprule and \botrule, respectively. And there is a standard rule to appear below the column heads and above the column—\colrule. If there are no column heads, use \colrule above the columns; always use \toprule in conjunction with \colrule, never alone.

There are also two commands to provide for sufficient vertical space between a rule and neighboring text: use the \frstrut command in one of the cells in the row of the alignment immediately following a \toprule or \colrule. And use the \lrstrut command in one of the cells in the row of the alignment immediately preceding a \colrule or \botrule.

A sample table employing these commands follows:

```
\begin{tabular}{@{}lc@{}}%
\toprule
\multicolumn{2}{@{}c@{}}{Thermal model}\\
\cline{1-2}%
\multicolumn{1}{@{}c}{Feature}&Number\\
\colrule
JLOCs        & 232\\
E23 elements & 498\\
E25 elements &  10\\
\botrule
\end{tabular}%
```

When formatted, it appears as

Thermal model	
Feature	Number
JLOCs	232
E23 elements	498
E25 elements	10

For more details on alignments, see the section "Alignments" in the User Reference.

3.7 CROSS REFERENCES

The usual LaTeX mechanism for cross references involves the \label and \ref commands. NASATeX provides for a more descriptive way of referring to chapters, sections, figures, tables, equations, and references. This is needed because of the different ways that target journals refer to standard elements such as figures, tables, and equations. By using the descriptive tools, you give NASATeX the ability to make adjustments to accomodate the target journal automatically.

For instance, if you set an equation with

```
\begin{equation}
{\bf\Psi}=\nabla\psi
\label{eqn:wave}%
\end{equation}
```

then you could refer to this as \eqnref{eqn:wave}. If the reference to the equation comes at the beginning of the sentence, you "spell" the command with a capital "R": \eqnRef{eqn:wave}. When the cross reference is not part of the grammar of the sentence, but is an aside, you use the * form of the command: \eqnref*{eqn:wave}. Thus,

```
derive from \eqnref{eqn:wave} the exact solution.
\eqnRef{eqn:wave}, however, has a singularity,
something we noted already \eqnref*{eqn:wave}.
```

formats like this:

> derive from equation (5.1) the exact solution. Equation (5.1), however, has a singularity, something we noted already (eq. (5.1)).

You can refer to a list of equations with, for example, \eqnref{eqn:one,eqn:two,eqn:three}, or to a range of equations, \eqnref{eqn:one-eqn:three}, or to a mixture of the two, \eqnref{eqn:one,eqn:two-eqn:three}. NASATeX automatically inserts the correct punctuation and conjunctions. So, for example, the above text will format as

> for example, \eqnref{eqn:one,eqn:two,eqn:three},
> or to a range of equations, \eqnref{eqn:one-eqn:three},
> or to a mixture of the two, \eqnref{eqn:one,eqn:two-eqn:thr

The following table gives the correct cross-reference command for each element:

To Refer to a	Use
\chapter	\chpref
\section	\secref
Figure	\figref
Table	\tabref
equation or eqnarray	\eqnref
\bibitem	\citeref

For a more detailed discussion of the cross referencing tools, see the section "Cross References" in the User Reference.

3.8 INDEXING

LaTeX's basic indexing command is used as follows:

```
text\index{index term} more text
```

To ensure correct pagination of the index, the \index command should always immediately follow a text word. Avoid putting an \index command in the argument of a macro, such as \section.

An extension to the \index command allows you to have a multilevel index entry:

```
\index{cake@chocolate}
```

You may create entries to an arbitrary depth, although accepted style sets a limit of three levels. This convention makes the @ character a reserved character.

Another extension allows you to explicitly specify the collation of an entry by supplying an optional argument to \index. The command

```
\index[key]{term}
```

will collate like key, but will be formatted like term. You must give only character data within the optional argument.

If you wish to specify that a term is to be indexed over a range of pages, you may use the \beginindex and \endindex commands. Be sure that the arguments of the two commands are precisely identical in all respects.

An index synonym is an index entry like "Gateau Bernstein, see Chocolate Cake." Obtain it with the command,

```
\indexsyn{Gateau Bernstein}{Chocolate Cake}
```

The \sindex command is a vehicle for specifying that this instance of the term being indexed is special.

For more information on the indexing commands, see the section "Indexing" in the Users Reference.

3.9 THE BIBLIOGRAPHY

The usual LaTeX commands for handling the bibliography are in place, but the format is slightly changed to accomodate the needs of NASA's multiple-use formatting system. The bibliography is marked up as follows:

\begin{thebibliography}{*sample label*}
\bibitem[*bib label*]{*key*}*content*
⋮
\end{thebibliography}

where *sample label* provides a way for the environment to gauge how much space to leave, if necessary, for the list devices of the bibliography. In the \bibitem command, the optional argument is a label to be used when referring to the entry, e.g., the author's last name and year of publication. If using this scheme, your entries should appear in alphabetical order by author name, and you should use the \year command to set off the year:

```
\bibitem[Eppel\year{1981}]{Eppel}%
Eppel, J.C.: Research Aircraft
:
```

The optional argument is, of course, unneeded for numbered references; be sure that you are using the NUMREF document style option. The required argument to the \bibitem command is the key, for use in a \citeref command elsewhere in the document.

For a more detailed discussion of bibliographic references, see the section "Bibliography" in the User Reference.

PART TWO

USER REFERENCE MANUAL FOR NASATEX

CHAPTER 1

USER REFERENCE

1.1 INTRODUCTION

All of NASATEX's special commands (and some of LaTeX's as well) are described in detail in this reference. I have included only those LaTeX commands that have been modified by NASATEX or are essential to the markup of a simple document; in general, you should consult the LaTeX Reference to understand how to use LaTeX itself. I present these commands in the style of Appendix C of the LaTeX Reference (on pages 150–202); all of the general comments there are applicable here. Note in particular that when a command's arguments are surrounded by square brackets [ ], the argument (with its enclosing brackets) is optional and may be omitted. Similarly, if a command is followed by asterisk *, or an environment name has a trailing *, the asterisk is optional and serves to modify the meaning of the command.

None of the new commands introduced by NASATEX is fragile.

1.2 DOCUMENT STRUCTURE

NASATEX shares LaTeX's approach to document structure by having a *preamble* followed by *document content*, with the latter set off by `\begin{document}` and `\end{document}` statements. Your overall document structure will then be

preamble
`\begin{document}`
document content
`\end{document}`

The purpose of the preamble is to specify to the formatter details that affect the processing of the document as a whole, such as what the intended format is and whether to process only a subset of the files. The document content will contain all commands that actually produce formatted output.

1.2.1 Partial Processing

LaTeX's `\include` and `\includeonly` commands work as usual. In addition, `\include` has an * variant indicating that, `\includeonly` statement notwithstanding, the document portion is *not* to be processed. You may have any number of `\includeonly` statements; NASATEX processes *any* file mentioned in any of the `\includeonly` statements. The `\include*` and `\includeonly` extensions give you many more ways to controlling processing. While developing a document, you can use an * to modify every `\include` command in your driver, and simply remove the * from those document portions that you wish to proof. Or you may employ multiple `\includeonly` commands to specify which ones to process.

The preamble command `\includeall` overrides the `\includeonly` statements and the `\include*` commands, forcing LaTeX to process all of the `\included` files and eschewing the `\clearpage` that the `\include` command usually forces. This means that a larger class of documents may be prepared via partial processing: you can divide a document into `\included` parts for partial processing during the development stage and use the `\includeall` command to format the document as a whole when the document is complete. Note that inserting `\includeall` means that LaTeX writes a new *jobname*`.aux` file that incorporates all of the document's auxiliary information, so you will have to process your document through TEX at least twice after inserting `\includeall`.

As an example of these commands, consider the following:

```
\includeonly{foo}
\includeonly{bar}
% \includeall
\begin{document}
\include{foo}
\include*{fud}
\include*{bar}
\include{baz}
\end{document}
```

The files `foo.tex`, `fud.tex`, `bar.tex`, and `baz.tex` are all candidates for processing, but `fud` and `bar` are excluded by the `\include*` syntax. The presence of the `\includeonly` statements means that `baz` will not be included either, so only `foo` will be processed this run. Note that if the comment character (`%`) is removed from the `\includeall` line, all four files will be processed and no page breaks will be inserted between the files.

1.3 PREAMBLE COMMANDS

There are three classes of preamble commands: \documentstyle commands, process control commands, and data commands. The first class specifies the publication for which the document is to be formatted, the second determines how the document will be processed, and the third specifies actual content, like the document's title, author, etc.

1.3.1 Document Styles

NASATEX's document style format is similar in spirit to that of LaTeX's article style, and has most of the latter's settings preloaded. The following table summarizes the different document styles currently supported. Each document style corresponds to a particular publisher. Simply specifying the publisher to which your document is to be submitted will generally suffice to determine all necessary publisher-specific formatting choices.

When submitting to	Use document style
NASA	NASA
AIAA	AIAA
AHS	AHS

Each document style contains several possible options, although these options are rarely needed, because the main document style automatically makes the appropriate default selections. A NASA document will rarely need anything beyond the TP document style option: the default is TM. By the same token, an AIAA or AHS document will generally need only a conference or typescript document style option.

Use the following document style options only with the NASA document style:

Option	Meaning
TP	Technical Publication
TM	Technical Memorandum

The other document style options listed in the following table, can be used appropriately with any of the main document styles. Aside from conference and typescript, use them only when the formatting of the selected document style must be modified for some exceptional case.

Option	Meaning
conference	Format is conference camera-ready.
typescript	Format is a typescript (wide margins, large type) for journal submissions.
twocolumn	Page layout is double-column. Has been needed only for a TM in two columns.
onecolumn	Page layout is single-column. Has been needed only for a TP in one column (rare).
NUMSECTION	Sections are to be numbered.
NUMREF	References are to be numbered.
UNNUMREF	References are to be unnumbered. This is the default for NASA documents.
collecttables	Tables are all to be placed at the end of the document.
collectfigures	Figures are all to be placed at the end of the document.

1.3.2 Process Control

The following document styles control various aspects of processing, such as whether fresh auxiliary files are to be generated by LaTeX, whether art is to be inserted on the formatted page, and whether a ruled box is to be set around each piece of art (as a diagnostic). They generally do not affect a document's pagebreaks, and are provided as a convenience for the author or typist. These options can be used appropriately with any of the main document styles;

Option	Meaning
nofiles	The auxiliary and other generated files are not to be altered this run.
noinsert	Placed electronic art is not to be printed. See section 1.9.
guide	Artwork sizes are to be shown on the hardcopy, for draft purposes. See section 1.9.

1.3.3 Data Commands

To specify the title of your document, the authors, etc., use the following commands. They must appear within the preamble of your document (before the \begin{document} statement). You can think of this information as remaining in TEX's memory during the processing of your document, where it can be accessed any time it is needed.

\title specifies the title of the document.

```
\title{\NASATeX\ Document System}%
```

\subtitle specifies the subtitle of the document.

```
\subtitle{Users Manual and Reference}%
```

\author specifies authors' names.

```
\author{Arthur Ogawa}%
```

\and ties together authors' names within the argument of the \author command.

```
\author{Arthur Ogawa\and Rachel Goldeen}%
```

\authortitle specifies an author's title (footnoted in AIAA paper); e.g.,"Member, AIAA" or "Captain, USAF".

```
\author{Arthur Ogawa\authortitle{Ph.D.}}%
```

\affiliation specifies an author's affiliation. You can use \\ to indicate pleasing linebreaks.

```
\author{A\@. Ogawa\affiliation{\TeX Con}}%
```

\submitted specifies the journal to which this document will be submitted. Applies to a NASA publication that willalso be published elsewhere.

```
\submitted{Computer Composition}%
```

\pubnumber specifies the serial number of this document.

```
\pubnumber{174BYR}%
```

\pubdate specifies the publication date (on cover of NASA publications).

```
\pubdate{1 June 1991}%
```

\copydate specifies the author's completion date for this publication (for terminal ending and Report Documentation Pages (RDP) in a NASA TP).

```
\pubdate{17 May 1991}%
```

1.4 FRONTMATTER

Standard LATEX has no means of designating a portion of a document as front matter, so NASATEX introduces the frontmatter environment to do so. The commands that may appear within front matter are as follows:

Option	Meaning
\maketitle	Format a title page. In NASA documents, both cover and title page will be formatted.
\tableofcontents	Format a table of contents.
\listoffigures	Format a list of illustrations.
\listoftables	Format a list of tables.

The order of appearance of these commands determines the actual order to the front matter elements; they appear in the above table in their preferred order. Note that if you request a table of contents, it is automatically compiled for you by LaTeX from the sectioning commands in your document. The same is true for a list of figures and a list of tables; the former are derived from the Figure environments, the latter from the Table environments in your document.

Here is an example of how you may mark up your frontmatter:

```
\begin{frontmatter}%
\maketitle
\tableofcontents
\end{frontmatter}%
```

1.5 SECTIONING

LaTeX's standard set of sectioning commands comprises \part, \chapter, \section, \subsection, \subsubsection, \paragraph, \subparagraph, and \subsubparagraph, all of which are also part of NASATEX, although the \part and \chapter commands are usually not needed in an article, and \subparagraph and \subsubparagraph commands are not recommended. Each of these commands has been enhanced with an option to independently control the running header which may take the title of the current document portion as its text. (For instance, it is common in some books to set the title of the current section in the running head.) If the title of the current section is too long for the given page width, you may specify an abbreviated section title for the current page in the optional argument to the \section command:

```
\section[Abbreviated title]{Full section title}
```

LaTeX's standard set of sectioning commands has been supplemented with environments for structures that commonly appear in NASA's technical documents, namely Summary, nomenclature, and Conclusion.

The Summary environment contains a synopsis of the document and is also used where an abstract is called for. If the document's summary is to be formatted as part of the title page, the Summary environment must appear in the preamble, where it can communicate properly with the \maketitle command. Otherwise, place the Summary environment at the point in the document where you want the summary to appear, usually it immediately follows the frontmatter environment.

Here is an example of a Summary environment:

```
\begin{Summary}
This paper describes recent advances
in calculating closed-form solutions
to the nonlinear Schr\"odinger equation.
\end{Summary}
```

The nomenclature environment is for explaining the mathematical terms used in your document. It presents a two-column tabular-like environment that can break over pages. The left column is in math mode, the right is a paragraph:

```
\begin{nomenclature}
term&meaning\\
term&meaning
\end{nomenclature}
```

If the material in either column is too long to fit into that column, it will be broken into paragraphs.

The width of the left column has a default value of 0.75 inches. To override this value, specify the new width in an optional argument to the nomenclature environment. The right column always fills out the text width. Here's an example of the nomenclature environment in which the left column's is set on a width of 25 points:

```
\begin{nomenclature}[25pt]
⋮
\end{nomenclature}
```

The nomenclature will carry the heading "Nomenclature"; the \nomenhead command allows you to change the text of this heading to suit your special needs:

```
\nomenhead{Terms}
\begin{nomenclature}
⋮
\end{nomenclature}
```

Note that the * form of the nomenclature environment is used in conjunction with the equation or eqnarray environment to provide the common "where..." construct; see the section "Math".

The Conclusion environment will contain the conclusions for your document (and will be followed automatically by the terminal ending if your document is a NASA Technical Paper). Here is an example of the Conclusion environment:

```
\begin{Conclusion}%
The downwash slope at the low-tail position
is about 1.5 to 2 times the high T-tail position.
\end{Conclusion}%
```

NASATEX follows LaTeX's way of delineating the appendix by means of the \appendix command. Thus, if your document has appendices, type

```
\section{A Chapter}
⋮
\section{Another Chapter}
⋮
\appendix
\section{An Appendix}%
⋮
\section{Another Appendix}%
⋮
```

In addition, NASATEX provides for the special case of a single appendix: \appendix*. Thus, if your document has exactly one appendix, type

```
\section{A Chapter}
⋮
\section{Another Chapter}
⋮
\appendix*
\section{A Single Appendix}%
⋮
```

1.6 MATH

NASATEX adheres to LaTeX's way of marking math formulas. The recommended way of marking an in-line math formula is with the \(and \) commands, rather than with TeX's $ escape, because this notation allows automatic checking to see that math formulas are properly closed. Emacs (on Unix and DOS), Epsilon (on DOS), and QUED/M (on Macintosh) all provide facilities for checking proper balancing of the delimiters used in LaTeX files. See the section "Checking your delimiters" in the User Guide.

Display math formulas should appear within equation or eqnarray environments, which will automatically apply an equation number. Do not insert a blank line immediately before a display math equation. If you need to insert white space to make your TeX file more readable, insert a comment line.

If you have an exceptional equation that is not to be numbered, you may use NASATEX's * form of these environments—the equation number will be suppressed. Thus, for an unnumbered equation, type

```
\begin{equation*}%
Your math expression here
\end{equation*}%
```

NASATEX also provides a subeqnarray environment, for those cases in which an equation is presented in parts:

```
\begin{subeqnarray}%
this line will be labeled, e.g., 1a\\
and this line will be labeled 1b\\
and this line will be labeled 1c\\
\end{subeqnarray}%
```

NASATEX has a simple way of obtaining certain math symbols in boldface; use the \bf font switch. For example, type

```
\begin{equation*}%
R_{\theta_e}=
 {R_{\theta_s}+R_{\theta_e}
  \over\bf R_{\theta_s}+R_{\theta_e}
  }
\end{equation*}%
```

if you want to obtain

$$R_{\theta_e} = \frac{R_{\theta_s} + R_{\theta_e}}{\mathbf{R}_{\mathbf{s}} + \mathbf{R}_{\mathbf{e}}}$$

Note that the \bf font switch applies to Roman and Greek letters only, not to math delimiters and relations.

Standard LaTeX disables two of Plain TeX's math commands, \eqalign and \displaymath. These commands have been restored in NASATEX.

Never use the \eqno and \eqaligno commands. Both defeat the automatic numbering and cross-referencing capabilities of LaTeX.

1.7 LISTS

LaTeX's standard features suffice for lists; the commonly-used environments will be `enumerate` for numbered lists, `itemize` for bulleted lists, and `description` for titled lists. As always, the `\item` command indicates the beginning of a new item in the list. Lists may be nested, but the best practice is to limit nesting to two levels.

Here is an example of a numbered list with the `enumerate` environment:

```
\begin{enumerate}
\item This is the first item in the list.
\item This is the second item in the list.
\end{enumerate}
```

Here is an example of a bulleted list with the `itemize` environment:

```
\begin{itemize}
\item This is an item in the list.
\item This is another item in the list.
\end{itemize}
```

Here is an example of a titled list with the `description` environment; note that the `\item` macro takes an optional argument specifying the title of the item:

```
\begin{description}
\item[Gnu]This is an item in the list.
\item[Dodo]This is another item in the list.
\end{description}
```

1.8 FLOATS: FIGURES AND TABLES

The NASATeX package distinguishes a figure or table, which is usually numbered and has a caption or title, from the material that is actually placed therein, like artwork or tabular material (an alignment). In NASATeX, figures and tables are expressed with more structure than in LaTeX in that a `Figure` or `Table` always has a *caption* argument and a *key* argument. A `Figure` or `Table` may therefore contain only one *caption*; subcaptions are provided for separately. A figure should be be marked up as follows:

`\begin{Figure}`{*caption*}{*key*}
content
`\end{Figure}`

The *key* argument is effectively used as the argument of a `\label` command. It enables you to cross-reference this figure using the `\figref`{*key*} command. Even if you do not wish to specify a *key* for your figure (for example if it is never referred to), you must still supply a pair of braces ({}) as a placeholder for this argument. Similarly, if for some reason you wish your figure to have no caption, you must supply a pair of braces ({}) as a placeholder for the caption.

LaTeX's optional placement parameters, (`h`, `t`, `b`, and `p`) can be applied to the `Figure` environment. However, in NASATeX the meaning of the `t` option has been changed. In standard LaTeX, the `t` placement parameter would instruct LaTeX allow the figure be placed at the top of the *current* page; in NASATeX, this has been changed to the top of the *next* page. The reason for this change is that most page layout rules specify that a figure is to be placed *after* the callout for (or reference to) the figure. NASATeX ensures that you will accomplish this by simply placing the `Figure` environment after the respective callout.

As with LaTeX, you may optionally use the * modifier to the environment name to signify that the figure is to span the full page width of a two-column layout. NASATeX, unlike LaTeX, allows either top or bottom placement for full-page-width floats.

NASATeX also provides for specifying optional caption text (to be set in the list of figures) when this text is to read differently from the caption set under the figure itself. A * modifier signifying that the figure is to be unnumbered is a further option. One caveat: if you specify the optional caption, you must explicitly specify the placement parameter, in order to avoid ambiguity. A sample `Figure` environment using all these options is:

`\begin{Figure*}[hbt]`
*[*optional caption*]{*required caption*}
{*key*}
content
`\end{Figure*}`

1.8.1 Special figure-numbering tools

This section explains page makeup of two-column documents containing full-page-width figures that are to be set at the bottom of the page. It tells how to control the placement of such figures and how to control the numbering of such figures in special cases.

Because of LaTeX's float placement algorithm, the Figure* environment must be located early enough in your file to ensure that the figure can appear at the top or bottom of a given page. How early is "early enough"? The answer is, the environment must be processed before any text is set on the given page. LaTeX can then properly debit the space available for text on that page, a calculation that cannot be re-done once type is set on the page.

Occasionally, therefore, you may find it necessary to put the Figure* environment earlier in the LaTeX file than another Figure (no *) environment that will actually place its figure earlier in the formatted document. NASATeX's \Figurelabel command provides a way to ensure the proper numbering sequence for your figures.

To see how this works, suppose you have a single-column width figure (Figure 1) that is small enough to be placed in one of the columns of, say, page 2 of your document. You also have a full-page-width figure (2) that you wish LaTeX to place at the bottom of this same page. Now, in order to place Figure 2 on page 2, you must put the corresponding Figure* environment 'way back with the text of page 1. If you process this file as it is, the full-page-width figure will be numbered Figure 1 instead of Figure 2, as it should be. To remedy this situation, alter the markup of the Figure* environment as follows:

```
\begin{Figure*}*{caption}{pagewidth}
content
\end{Figure*}
```

Note that the caption is preceded by a *, indicating that the figure is unnumbered, but nonetheless the key is specified. This markup signifies that the figure is actually to be numbered, but that the number of the figure is to be determined by the value of the specified key pagewidth. Now insert the following command somewhere *after* the Figure environment for Figure 1:

```
\Figurelabel{pagewidth}
```

Note that the argument of this command coincides with the *key* argument of the above Figure* environment. NASATeX will now automatically assign a value of "2" to the key pagewidth because its \Figurelabel command appears after the Figure environment for Figure 1. Thus the full-page-width figure at the bottom of the page will be numbered Figure 2 as you wanted.

The Table environment has its own tool for making such adjustment; it is called the \Tablelabel, as you might expect.

1.8.2 Splitting a figure over pages

In some cases, a single figure will be split into several parts; the caption of the first parts will be titled, say, "Figure 42", and subsequent ones, "Figure 42 (continued)", with the final part titled "Figure 42 (concluded)". Splitting a figure into parts is done with the \splitfigure command. The * form, \splitfigure*, is used to indicate the last of the splits. An example is

```
\begin{Figure*}*{caption}{pagewidth}
\dropeps{file1a}
\splitfigure
\dropeps{file1b}
\splitfigure
\dropeps{file1c}
\splitfigure*
\dropeps{file1d}
\end{Figure*}
```

1.8.3 Multiple pieces of art within a figure

Authors often wish to place more than one piece of art within a figure. To facilitate this, NASATeX provides the command \ArtPart, which also automatically numbers the "subfigures" and sets subcaptions for them. An example of the \ArtPart command is

```
\ArtPart{caption}{content}
```

where *caption* represents the subcaption to be applied to this piece of art, and *content* is the art itself, usually a \dropArt or \dropeps command.

Many such commands may appear within a single figure; NASATeX automatically places pieces side-by-side or stacked, depending on the actual size of the art.

The Table environment functions entirely analogously to the Figure environment; the following is a summary of commands for both figures and tables, showing the correspondences between the two environments.

Figure	Table	Notes
Figure	Table	main float environment
\Figurelabel{*key*}	\Tablelabel{*key*}	automatically generates the next number in the series and applies it to the *key*
\splitfigure*	\splittable*	breaks the float at this point, continuing the float on the next page
\ArtPart{<caption>}{<content>}		places a subportion of a float, with a caption

1.9 ART

Publishers refer to photographs and diagrams appearing in a book or article as art. Usually art appears as the content of a Figure environment. LaTeX provides for art using the picture environment. NASATeX provides for two types of art: (1) traditional manually-placed art (manual art), and (2) electronically generated and placed art (electronic art). In some installations of NASATeX, the picture environment is not a part of the base format file and must be incorporated explicitly. To do this, place a \documentstyle{picture} command in your document's preamble.

Rather than use the picture environment, the Technical Information Division (TID) encourages authors to generate their art either manually or via a Visual Information Specialist according to NASA guidelines. The preferred vehicle for electronic art is an Encapsulated PostScript file in format of Adobe Illustrator.

The NASATeX commands for placing manual art are the \dropArt and \dropArt* commands, which allow you to specify the width and height of your manual art and to specify a text string identifying the art:

\dropArt(*width*,*height*,0){*identifier*} creates a box of the specified height and width into which manual art can be placed on the camera-ready copy. If the document style guide is given, TeX will put rules around the box and place the identifier at the center.

\dropArt*(*width*,*height*,0){*identifier*} Uniformly scales a box of the specified dimensions to the current \hsize or \textwidth, whichever is more constraining. If the document style guide is given, TeX will put rules around the box and place the identifier at the center.

Electronic art is placed with the \dropeps command, which allows you to specify the size of the art, its magnification, and whether to scale it to fit available space. The eps in \dropeps stands for Encapsulated PostScript. The \dropeps command works only for Encapsulate PostScript files, not other types of electronic art formats such as TIFF or PICT files. It will also fail for PostScript files that do not conform to the Adobe Encapsulation standard. If the electronic art is in the wrong format, you won't get an error message, but the document will not print correctly. If you are using Adobe Illustrator, be sure to save your file *with* an EPSF header.

\dropeps{*filename*} places the EPS file specified by *filename* at a scale of 100%.

\dropeps(*scale*){*filename*} places *filename* at the specified scale (where 1.0 = 100%). If the specified scale is nil, unity is used.

\dropeps*{*filename*} places *filename* uniformly scaled to the current \hsize or \textheight, whichever is more constraining.

\dropeps*(*width*,*height*,0){*filename*} places *filename*, scaled to fit within the specified box. The art is uniformly scaled, horizontally and vertically, so it will not necessarily fill the entire box.

The dimensions are specified in terms of \unitlength. As with the \dropArt commands, if the document style option guide is given, a ruled box will be put around the art, and the name of the file will be printed at the center. This option is useful in debugging.

The document style option noinsert tells TeX not to print any electronic art, just to leave a blank space of the proper size. If this option is not specified, TeX will automatically include any electronic art on the printed page. Because electronic art often takes a long time to print, specifying `noinsert` as a document style option will speed up printing of draft copies for which the art is not necessary.

Here is a summary of commands relating to art:

`\documentstyle{picture}` must be placed in the document's preamble in order to use LaTeX's `picture` environment (not recommended).

`\documentstyle[guide]`{*style*} is a document style option that puts guide rules around the art and places the identifier or file name at the center.

`\documentstyle[noinsert]`{*style*} is a document style option that prevents electronic art from being previewed or printed out.

`\dropArt`(*width*,*height*,0){*identifier*} creates a box of the specified height and width into which manual art can be placed on the camera-ready copy.

`\dropArt*`(*width*,*height*,0){*identifier*} uniformly scales a box of the specified dimensions to the current `\hsize` or `\textwidth`.

`\dropeps`{*filename*} places the file specified by *filename* at a scale of 100%.

`\dropeps`(*scale*){*filename*} places *filename* at the specified scale (where 1.0 = 100%). If the specified scale is nil, uses 100%.

`\dropeps*`{*filename*} places *filename* uniformly scaled to the current `\hsize` or `\textheight`, whichever is more constraining.

`\dropeps*`(*width*,*height*,0){*filename*} places *filename*, scaled to fit within the specified box.

1.10 ALIGNMENTS

The usual content of a `Table` is tabular material, or alignment. The LaTeX tabular environment has been enhanced with some additional commands, making alignments more descriptive and consequently more standardized. Standard rules need to be inserted above and below an alignment; the commands are `\toprule` and `\botrule`, respectively. A standard rule also must be inserted below the column heads and above the columns; the command is `\colrule`. Note: if there are no column heads, use `\colrule` above the columns. Always use `\toprule` in conjunction with `\colrule`, never alone.

There are two commands to provide sufficient vertical space between a rule and neighboring text. Use the `\frstrut` command in one of the cells in the row of the alignment immediately following a `\toprule` or `\colrule`. Use the `\lrstrut` command in one of the cells in the row of the alignment immediately preceding a `\colrule` or `\botrule`.

A sample table using these commands follows:

```
\begin{tabular}{@{}lc@{}}%
\toprule
\multicolumn{2}{@{}c@{}}{Thermal model
 \frstrut\lrstrut
 }\\
\cline{1-2}%
\multicolumn{1}{@{}c}{Feature}&
 Number\frstrut\lrstrut\\
\colrule
\frstrut
JLOCs        & 232\\
E23 elements & 498\\
\lrstrut
E25 elements &  10\\
\botrule
\end{tabular}%
```

When formatted, this table appears as:

Thermal model	
Feature	Number
JLOCs	232
E23 elements	498
E25 elements	10

Here is a summary of commands related to tabular material. Further information on commands that are a part of standard LaTeX may be found in the LaTeX manual, pages 182–185.

`tabular` is the main environment for tabular material (standard LaTeX). Usage:

`\begin{tabular}`[*position*]{*cols*}

```
cellk...\\...
\end{tabular}
```

\toprule, \colrule, \botrule set rules at the top of the tabular material(\toprule), just below the column heads (\colrule), and at the end of the tabular material(\botrule). Always begin your tabular environment with either \toprule or \colrule, and always end it with \botrule. The rows of the tabular environment between the \toprule and \colrule commands are taken to be the column heads and will be repeated if the tabular material is split. These commands must appear either immediately after a \\ row-ending command or at the very beginning of the environment.

\frstrut, \lrstrut provide the correct amount of space above (\frstrut) or below (\lrstrut) the cell in which they appear. The \frstrut command is to be used in some cell of the row immediately following a \toprule or \colrule. The \lrstrut command is to be used in some cell of the row immediately preceding a \botrule. If the cell is set on multiple lines, invoke \frstrut in the top line and \lrstrut in the bottom line of the cell. This usually implies beginning the cell with \frstrut and ending it with \lrstrut.

\cline{<col1>-<col2>} draws a horizontal line across the specified columns (standard LaTeX).

\multicolumn{<ncols>}{<col>}{<text>} spans *ncols* columns using *col* column formatting, with *text* (standard LaTeX).

\splittable splits the tabular environment, and the Table environment containing it, to allow for a page break. The \splittable command must immediately follow the \\ row-ending command. This is the only context in which the \splittable command is allowed inside a tabular environment.

1.11 CROSS REFERENCES

The usual LaTeX mechanism for cross referencing involves the \label and \ref commands. The \label command has not been changed; however, NASATeX gives you a more descriptive form of the \ref command to refer to chapters, sections, figures, tables, equations, and bibliographic entries. For example, \chpref refers to chapters, \secref refers to sections, and so on. (For a complete list, see the table later in this section). This is needed because different publishers have different ways of refering to standard elements such as figures, tables, and equations. The descriptive tools, allow NASATeX to accommodate the target publication automatically.

Each \ref command has three forms: \...ref for standard references, \...Ref for references beginning a sentence, and \...ref* for parenthetical references. For instance, if you set some equations with

```
\begin{eqnarray}
{\bf\Psi} &=& \nabla\psi\label{eqn:one}\\
      E &=& mc^2\label{eqn:two}\\
 \int xdx &=& \frac{1}{2}x^2 + c\label{eqn:three}
\end{equation}
```

you refer to them as \eqnref{eqn:one}, \eqnref{eqn:two} and \eqnref{eqn:three}. If the reference to the equation comes at the beginning of the sentence, you "spell" the command with a capital "R": \eqnRef{eqn:one}. When the cross-reference is not part of the grammar of the sentence, but is an aside, you use the * form of the command: \eqnref*{eqn:one}. Thus,

```
derive from \eqnref{eqn:one} the exact solution.
\eqnRef{eqn:three}, however, has a singularity,
something we noted already \eqnref*{eqn:two}.
```

formats like

> derive from equation (1.1) the exact solution. Equation (1.3), however, has a singularity something we noted already (eq. (1.2)).

You can refer to a list of equations, a range of equations, or to a mixture of the two, withthe following syntax:

List: \eqnref{eqn:one,eqn:two,eqn:three}

Range: \eqnref{eqn:one-eqn:three}

Combination: \eqnref{eqn:one,eqn:two-eqn:three}

NASATeX automatically inserts the correct punctuation and conjunctions. Thus, the above text formats like this:

List: equations (1.1), (1.2), and (1.3)

Range: equations (1.1)–(1.3)

Combination: equations (1.1) and (1.2)–(1.3)

The following table gives the correct cross-reference command for each element.

To Refer to a	Use
`\chapter`	`\chpref`
`\section`	`\secref`
`Figure`	`\figref`
`Table`	`\tabref`
`equation` or `eqnarray`	`\eqnref`
`\bibitem`	`\citeref`

Note that in the cases of the `Figure` and `Table` environments, you do not use a `\label` statement for the main environment; this function is provided in the arguments of the environment itself.

1.12 INDEX

LaTeX's basic indexing command is used as follows:

text`\index{`*index entry*`}` *more text*

To ensure correct page references in the index, the `\index` command should always immediately follow a text word; this prevents the possibility of a page break between the index command and the text to which it refers. When typing several consecutive `\index` commands, be sure to prevent any whitespace between entries. This:

```
sample\index{entry}\index{exit} text
```

Not this:

```
sample\index{entry} \index{exit} text
```

When alphabetizing index entries, the indexer ignores case, white space and TeX commands. Thus, Listerine, list processor, and `ListType` appear in that order. Unique entries are not, however, lumped together in the index: Ångstrom and angstrom, for example, will have separate entries. Conversely, when an entry is indexed on several different pages, the page references will be grouped under that one entry. For instance, if the command `\index{Jupiter}` occurs on pages 2, 10, 21, 22, 23, and 50, the index entry formats as

Jupiter, 2, 10, 21–23, 50

Avoid putting an `\index` command in the argument of another command (such as `\section`). There are two reasons why: first, if the argument to the command is a *moving argument* (in the sense explained in the LaTeX Reference), then LaTeX may attempt to write it into the table of contents or somewhere else where it not belong. A construct like

```
\section{Jupiter\index{Jupiter}}
```

is unsound because it instructs LaTeX to index "Jupiter" in the table of contents. Instead, type

```
\section{Jupiter}\index{Jupiter}
```

Second, if the argument of the `\index` command itself has TeX markup, such markup must be protected from expansion if fragile. This will not occur if the `\index` command is itself within the argument of another command. A construct like

```
\item{Jupiter\index{Jupiter{\small moon}}}
```

will cause TeX to halt processing with an error. Instead, type

```
\item{Jupiter}\index{Jupiter{\small moon}}
```

Always observe these limitations when using the `\index` command.

An extension to the `\index` command allows you to have multilevel index entries:

```
\index{cake@chocolate}
\index{cake@poppy seed}
```

produces

cake
  chocolate, 2
  poppy seed, 3

You may create entries to an arbitrary depth; accepted style would set a limit of three levels, however. This convention makes the @ character a reserved character.

Another extension allows you to specify the alphabetization of an unusual entry by supplying an optional argument to \index. The command

\index[*alphabetic spelling*]{*formatted spelling*}

will collate like *alphabetic spelling*, but will be formatted like *formatted spelling*. You can give only alphabetic characters within the optional argument. For example, the command

```
\index[Angstrom]{{\AA}ngstrom}
```

tells NASATEX to alphabetize "Ångstrom" just as it would "Angstrom".

To specify that a term is to be indexed over a range of pages, use the \beginindex and \endindex commands. Be sure that the arguments of the two commands are precisely identical in all respects.

An index synonym is an index entry like "Gateau Bernstein, *see* Chocolate Cake." Obtain it with the following command:

```
\indexsyn{Gateau Bernstein}{Chocolate Cake}
```

The \sindex command specifies that a given instance of the term being indexed is special. Using it results in an index entry whose page number is formatted in a distinctive way (e.g., boldface). In the earlier example about Jupiter, if the command on page 10 had been \sindex{Jupiter}, the formatted result in the index would look like this:

Jupiter, 2, **10**, 21–23, 50

You may also obtain such indexing over a range of your document via the \beginsindex and \endsindex commands.

Here is a summary of indexing commands:

\index{*entry*} puts *entry* into the index with a reference to the page on which the \index command occurs.

\index{*entry@subentry@subsubentry*} creates a multilevel index entry.

\index[*alphabetic spelling*]{*formatted entry*} ensures proper alphabetization of words that might confuse the index sorting program.

\beginindex{*entry*}, \endindex{*entry*} allows the indexing of *entry* over a range of pages. Do not use one command without the other.

\sindex{*entry*}, \beginsindex{*entry*}, \endsindex{*entry*} formats the page number of an index entry in a distinctive way, to add emphasis. The *s* stands for special.

\indexsyn{*entry*}{*synonym*} creates an index entry of the form "*entry*, see *synonym*."

1.13 BIBLIOGRAPHY

The usual LaTeX commands for handling the bibliography are in place, but the format is slightly changed to accommodate the needs of NASATEX's multiple-use formatting system. The bibliography is marked up as follows:

\begin{thebibliography}{*sample label*}
\bibitem[*bib label*]{*key*}*content*
⋮
\end{thebibliography}

where *sample label* provides a way for the environment to gauge how much space to leave for the labels of the bibliography. In the \bibitem command, the optional argument is a label to be used when referring to the entry, e.g., the author's last name and year of publication. If you use the (author, date) reference style, type your entries in alphabetical order by author name and use the \year command to set off the year:

```
\bibitem[Eppel\year{1981}]{Eppel}%
Eppel, J.C.: Research Aircraft
```

If you use the numbered reference style, use the NUMREF document style option, and arrange your \bibitem entries in the order you cite them in text. The optional argument is, of course, unneeded for numbered references, but it is good practice to to provide it in case the it is decided to switch to unnumbered references. The required argument to the \bibitem command is the key, for use in a \citeref command elsewhere in the document. Here is a sample bibliography showing how to enter two common types of bibliographic references

```
\begin{thebibliography}{}
```

```
\bibitem[Knuth\year{1986}]{Kn86}
Knuth, D. E. 1986. {\em The \TeX book}.
 Addison-Weseley, Reading (MA).

\bibitem[Loeb et al.\year{1990}]{LGM}
 Loeb, Arthur~L.,  Jack~C. Gray,
  and Philip~R. Maillinson.\ 1990.\
 ``On the Icosahedron,
  the Pentagonal Dodecahedron,
  and the Rhombic Triancontahedron,''
  {\em Symmetry} {\bf 1}, 29--36.

\end{thebibliography}
```

PART THREE

SAMPLE DOCUMENTS

CHAPTER 1

NASA TECHNICAL PUBLICATION

An example of a NASA Technical Publication (TP) is presented here with both the TEX source code and the formatted output. The formatted pages are reproduced exactly as you would print them yourself, except reduced 80%.

NASA Technical Publication 100435

Effect of Surface Catalysis on Heating to Ceramic Coated Thermal Protection Systems for Transatmospheric Vehicles

A Controlled Study

David A. Stewart, William D. Henline,
Paul Kolodziej, and Elizabeth M. W. Pincha

May 1989

National Aeronautics and
Space Administration

NASA Technical Publication 100435

Effect of Surface Catalysis on Heating to Ceramic Coated Thermal Protection Systems for Transatmospheric Vehicles

A Controlled Study

David A. Stewart
NASA Ames Research Center, Moffett Field, California
William D. Henline
Sterling Software, Palo Alto, California
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Boeing Aerospace Company, Seattle, Washington

1989

National Aeronautics and
Space Administration

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Moffett Field, California, 94035-1000

CONTENTS

SUMMARY

Several reports have been written on the performance of the Quiet Short-Haul Research Aircraft, which show the advantages of upper-surface flowing or the propulsive-lift wing as it applies to lift, maneuverability, and short takeoff and landing.

INTRODUCTION

The Quiet Short-Haul Research Aircraft (QSRA) is one of the many research aircraft at NASA Ames Research Center. When the upper-surface blowing (USBO) project was originally conceived and initiated in 1974 (Eppel, 1981;Riddle, 1981;Cochrane, 1981;Riddle, 1987), the main objective was the proof-of-concept and development of a low-speed powered-lift data base, i.e., gathering performance and handling qualities data associated with takeoff and landing. The first downwash experiment was the aft-fuselage measurements. Riddle (1981), Cochrane (1981), and Riddle (1987) discuss the downwash tests, which were made at a nominal altitude of 8,000 ft, and at a series of 18 alpha (angle-of-attack) sweeps.

NOMENCLATURE

i_w angle of incidence; angle formed by zero lift chord and the longitudinal axis

α_{aw} ϵ γ θ angle of attack of the wing = $\alpha_\tau + i_w$

α_{TRUE} TRUE angle of attack = $\theta - \gamma$

ϵ downwash angle; difference between angle of attack at the wing and angle of attack at the tail

γ flightpath of aircraft relative to the horizon. $\gamma = \arcsin(\dot{h}_T/1.699V_T)$

θ aircraft (gyro) pitch attitude relative to the horizon

θ_p angle as measured from the longidinal axis of the downwash measurement probe to the relative wind

α_{TRUE} TRUE angle of attack = $\theta - \gamma$

ϵ downwash angle; difference between angle of attack at the wing and angle of attack at the tail

γ flightpath of aircraft relative to the horizon. $\gamma = \arcsin(\dot{h}_T/1.699V_T)$

θ aircraft (gyro) pitch attitude relative to the horizon

Subscripts

a absolute

p probe

t tail

T true

w wing

TECHNICAL APPROACH AND PROCEDURES

The first downwash experiment was the aft-fuselage measurements. Riddle (1981), Cochrane (1981), and Riddle (1987) discusses the downwash tests, which were made at a nominal altitude of 8,000 ft, and at a series of 18 alpha (angle-of-attack) sweeps.[1] The rake, an aerodynamically designed structure mounted to the aircraft aft-fuselage which held 6 probes to measure the movement of air, is shown in figures 1 and 2.[2]

Figures 3 and 4 show the probes in the T-tail position.

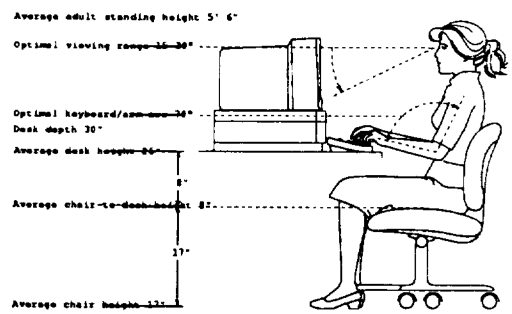

Figure 1. A test figure.

[1]The results show greater values of downwash as the USB settings are increased. Also, the $\Delta\epsilon/\Delta\alpha_{aw}$ slopes increase from 0.75 to 1.04.

[2]Also, the $\Delta\epsilon/\Delta\alpha_{aw}$ slopes increase from 0.75 to 1.04. The results show greater values of downwash as the USB settings are increased.

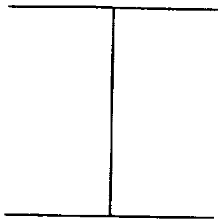

Figure 2. A full-page-width figure.

Table 1. Comparison of finite-element thermal and structural models for space shuttle orbiter wing.

Thermal model[a]	
Feature	Number
JLOCs	232
E23 elements	498
E25 elements	10

[a]A sample footnote for the table.

Table 2. Comparison of finite-element thermal and structural models for space shuttle orbiter wing.

Thermal model[a]	
Feature	Number
JLOCs	232
E23 elements	498
E25 elements	10

Table 2. Continued.

Thermal model[a]	
Feature	Number
JLOCs	232
E23 elements	498
E25 elements	10

Table 2. Concluded.

Thermal model[a]	
Feature	Number
JLOCs	232
E23 elements	498
E25 elements	10

[a]A sample footnote for the table.

RESULTS AND DISCUSSION

The parameters of prime concern of this report are downwash (ϵ) and wing alpha (α_{aw}). Sidewash angles and local dynamic pressures were also measured but are not addressed in this report.

Low Tail/Aft-Fuselage Location

Figure 4 shows downwash versus wing alpha for constant thrust (89% fan rpm) as the USB flap positions are varied. The results show greater values of downwash as the USB settings are increased from 0° to 60°.

$$x^2 + y^2 = z^2 \tag{1}$$

Also, the $\Delta\epsilon/\Delta\alpha_{aw}$ slopes increase from 0.75 to 1.04 as USB flap setting is increased from 0° to 60°.

$$x^2 + y^2 = z^2 \tag{2a}$$

$$a^2 + b^2 = c^2 \tag{2b}$$

$$d^2 + e^2 = f^2 \tag{2c}$$

As the USB flap setting increases there is a well defined difference in the downwash behind the inboard and outboard engines. At 60° USB flap, equations (2a), (2b), and (2c) give the downwash behind the inboard engine as 4-5° more than that behind the outboard engine.

Important information gained during this test includes the slope of $\Delta\epsilon/\Delta\alpha_{aw}$ for the various conditions and the variation of slope with varying thrust or USB flap settings. Table 3 shows a matrix of conditions arranged with increasing thrust horizontally and increasing USB vertically. It can be seen that the greatest $\Delta\epsilon/\Delta\alpha_{aw}$ slop is at maximum thrust (89% fan rpm) and 60° USB flap setting, the condition for the highest levels of wing powered lift. At a constnt thrust corresponding to 89% fan rpm, the range of $\Delta\epsilon/\Delta\alpha$

Table 3. Comparison of finite-element thermal and structural models for space shuttle orbiter wing.

Thermal model		Structural model[a]	
Feature	Number	Feature	Number
JLOCs	2289	JLOCs	232
K21 elements	1696	E23 elements	498
K31 elements	84	E25 elements	10
K41 elements	485	E31 elements	19
R31 elements	84	E41 elements	181
R41 elements	568	E44 elements	67

[a]A sample footnote for the table.

with increasing USB flap setting is from 0.75 (0° USB flap). For a constant 60° USB flap setting, power increases from 70% to 89% fan rpm cause an increase in $\Delta\varepsilon/\Delta\alpha_{aw}$ from 0.88 to 1.04. The typical QSRA takeoff and landing approach conditions are high-lighted in table 2. Table 3 shows the realtionship between thrust and percent fan.

T-Tail

The T-tail downwash experiment consisted of three separate flights because of the availability of only three pressure probes. For this reason, it was important to investigate the flight-to-flight correlation of data using a common probe position. Figure 5 shows correlation of downwash for two conditions: USB = 0°, fan at 60%, and USB = 50°, fan at 89%.

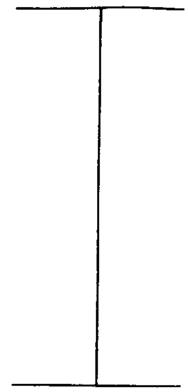

Figure 3. Another column-width figure.

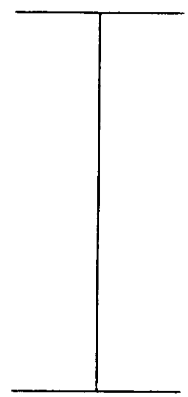

Figure 5. Another column-width.

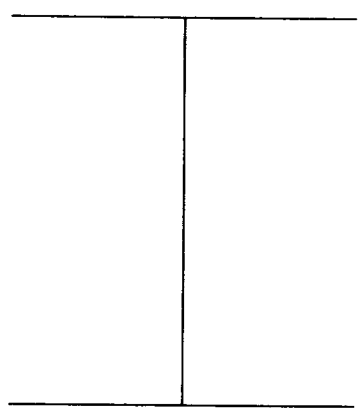

Figure 4. Another full-page-width figure.

Figure ?? shows the spanwise T-tail downwash variation at constant 89% fan rpm setting with increasing USB flap setting for all 6 probe positions. The downwash increases with USb flap setting, as in the low-tail position (fig. 4). However, the downwash magnitudes and the $\Delta\epsilon/\Delta\alpha_{aw}$ slopes are less at the T-tail location. Also, the distince inboard/outboard downwash magnitude difference seen at large USB flap settings at the low-tail position are not evident at the T-tail.

Table 2 shows a matrix of $\Delta\epsilon/\Delta\alpha_{aw}$ slopes for the tested conditions arranged with increasing thrust horizontally and increasing USB flap settings vertically. The largest $\Delta\epsilon/\Delta\alpha_{aw}$ varying from 0.45 to 0.78. The corresponding low-tail downwash slopes (tab. 2) are approximately 1.5 times greater than those at the T-tail (tab. 3) for 89% fan with varying USB flap setting.

Figure ??, a three-dimensional (3-D) plot of the downwash data obtained in both experiments, depicts a sheet of air as experienced by the T-tail and low-tail probes for the QSRA landing approach configuration (50^o USB flap, 59^o DSF and AEO at 70% fan rpm). 3-D data plot format shows the relatively consistent spanwise characteristics of the downwash fields with all engines operating. The magnitude of the downwash is greater at the low-tail position as is the downwash slope, $\Delta\epsilon/\Delta\alpha_{aw}$, 0.85 to 0.5.

CONCLUSIONS

1. The downwash angle increases with increasing USB flap setting and thrust, the two predominate wing lift increasers. The largest downwash occurs with maximum USB flap setting and thrust.

2. The downwash slopes, $\Delta\epsilon/\Delta\alpha_{aw}$, also increase with USB flap setting and thrust increases. There is also a tendency for slope increases as wing alpha increases.

3. The downwash slope, $\Delta\epsilon/\Delta\alpha_{aw}$, at the low-tail position is about 1.5 to 2 times the value of that at the the high T-tail position. This means that the low-tail position provides less stability than the high T-tail position. This would increase the need for a stability augmentation system (SAS) for a low-tail configuration. The trim changes would also be higher at the low-tail position increasing the need for a variable incidence horizontal stabilizer at the low-tail position. Automatic trim may be required as USB flap setting and thrust are increased on a low-tail configuration.

Ames Research Center
National Aeronautics and Space Administration
Moffett Field, California, September 15, 1988

APPENDIX

DOWNWASH CHARACTERISTICS

Important information gained during this test includes the slope of $\Delta\varepsilon/\Delta\alpha_{aw}$ for the various conditions and the variation of slope with varying thrust or USB flap settings. Table 3 shows a matrix of conditions arranged with increasing thrust horizontally and increasing USB vertically. It can be seen that the greatest $\Delta\varepsilon/\Delta\alpha_{aw}$ slop is at maximum thrust (89% fan rpm) and 60° USB flap setting, the condition for the highest levels of wing powered lift. At a constnt thrust corresponding to 89% fan rpm, the range of $\Delta\varepsilon/\Delta\alpha$ with increasing USB flap setting is from 0.75 (0° USB flap). At a constnt thrust corresponding to 89% fan rpm, the range of $\Delta\varepsilon/\Delta\alpha$ is from 0.75 (0° USB flap). For a constant 60° USB flap setting, power increases from 70% to 89% fan rpm cause an increase in $\Delta\varepsilon/\Delta\alpha_{aw}$ from 0.88 to 1.04. The typical QSRA takeoff and landing approach conditions are high-lighted in table 2. Table 3 shows the realtionship between thrust and percent fan.

T-Tail

The T-tail downwash experiment consisted of three separate flights because of the availability of only three pressure probes. For this reason, it was important to investigate the flight-to-flight correlation of data using a common probe position. Figure 5 shows correlation of downwash for two conditions: USB = 0°, fan at 60%, and USB = 50°, fan at 89%.

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Figure ??, three-dimensional (3-D) plot of the downwash data obtained in both experiments, depicts a sheet of air as experienced by the T-tail and low-tail probes for the QSRA landing approach configuration (50° USB flap, 59° DSF and AEO at 70% fan rpm). 3-D data plot format shows the relatively consistent spanwise characteristics of the downwash fields with all engines operating. The magnitude of the downwash is greater at the low-tail position as is the downwash slope, $\Delta\varepsilon/\Delta\alpha_{aw}$, 0.85 to 0.5.

REFERENCES

Eppel, J.C.: Quiet Short-Haul Research Aircraft Familiarization Document, Revision 1. NASA TM-81298, 1981.

Riddle, D.W.; Innis, R.C.; Martin, J.L.; and Cochrane, J.A.: Powered-Lift Takeoff Performance Characteristics Determined from Flight Test of the Quiet Short-Haul Research Aircraft (QSRA). AIAA Paper 81-2409, Nov. 1981.

Cochrane, J.A.; Riddle, D.W.; and Stevens, V.C.: Quiet Short-Haul Research Aircraft–The First Three Years of Flight Research. AIAA/NASA Ames VSTOL Conference, AIAA Paper 81-2625, Dec. 1981.

Riddle, D.W.; Stevens, V.C.; and Eppel, J.C.: Quiet Short-Haul Research Aircraft–A Summary of Flight Research Since 1981. SAE Paper 87-2315, in the proceedings of the International Powered-Lift Conference, SAE P-203, Dec. 1987.

```
% preamble---place all commands affecting processing here
%\nofiles
%\documentstyle[conference]{AIAA}%
%\documentstyle[typescript]{AIAA}%
%\documentstyle[conference]{AHS}%
%\documentstyle[typescript]{AHS}%
%\documentstyle[conference,copy4]{AIAA}%
%\documentstyle[TM,collecttables,collectfigures]{NASA}%
 \documentstyle[TP]{NASA}%
%\documentstyle[TM]{NASA}%
%\documentstyle[TP,NUMSECTION]{NASA}%
%\documentstyle[TM,NUMREF,NUMSECTION,typescript]{NASA}%
%\documentstyle[NUMREF]{}%
%\documentstyle[DRYDEN]{}%
 \documentstyle[insert]{}%
%\documentstyle[guide]{}%
%\traceheights
% end of preamble
%\traceoutput
%
\title{%
 Effect of Surface Catalysis on Heating\\
 to Ceramic Coated Thermal Protection Systems\\
 for Transatmospheric Vehicles
 }%
\subtitle{A Controlled Study}%
\author{%
 David A. Stewart\authortitle{Research Scientist}%
  \affiliation{NASA Ames Research Center\\Moffett Field, California}%
 \and
 William D. Henline\authortitle{Professional Staff}%
  \affiliation{Sterling Software\\Palo Alto, California}%
 \and
 Paul Kolodziej
  \authortitle{Research Scientist, Member AIAA}%
  \affiliation{NASA Ames Research Center\\Moffett Field, California}%
 \and
 Elizabeth M. W. Pincha\authortitle{Senior Test Engineer}%
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\begin{frontmatter}%
\maketitle
\tableofcontents
\end{frontmatter}%

\begin{Summary}
Several reports have been written on the performance of the Quiet Short-Haul
Research Aircraft, which show the advantages of upper-surface flowing or the
propulsive-lift wing as it applies to lift, maneuverability, and short takeoff and landing.
\end{Summary}
%
\section{Introduction}
The Quiet Short-Haul Research Aircraft (QSRA) is one of the many
research aircraft at NASA Ames Research Center. When the upper-surface
blowing (USBO) project was originally conceived and initiated in 1974
\citeref*{Eppel,Riddle81,Cochrane,Riddle87},
the main objective was the proof-of-concept and development of a
low-speed powered-lift data base, i.e., gathering performance and
handling qualities data associated with takeoff and landing.
The first downwash experiment was the aft-fuselage measurements.
\citeRef{Riddle81,Cochrane,Riddle87} discuss the downwash
tests, which were made at a nominal altitude of 8,000~ft, and at a series of~18 alpha
(angle-of-attack) sweeps.%

\begin{nomenclature}[2.5em]
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 i_{w}     &angle of incidence; angle formed by zero lift chord and the longitudinal axis \\
 \alpha_{aw}\,\epsilon\,\allowbreak\gamma\,\allowbreak\theta &angle of attack of the wing =
${\alpha}_{\tau} + i_{w}$ \\
 \alpha_{\rm TRUE}&TRUE angle of attack = $\theta - \gamma$ \\
 \epsilon  &downwash angle; difference between angle of attack at the wing and angle of attack at the
tail  \\
 \gamma    &flightpath of aircraft relative to the horizon. $\gamma = {\rm
arcsin}\>(\dot{h}_T/1.699V_{T})$ \\
 \theta    &aircraft (gyro) pitch attitude relative to the horizon \\
 \theta_{p}&angle as measured from the longidinal axis of the downwash measurement probe to the relative
wind \\
 \alpha_{\rm TRUE}&TRUE angle of attack = $\theta - \gamma$ \\
 \epsilon  &downwash angle; difference between angle of attack at the wing and angle of attack at the
tail  \\
 \gamma    &flightpath of aircraft relative to the horizon. $\gamma = {\rm
arcsin}\>(\dot{h}_T/1.699V_{T})$ \\
 \theta    &aircraft (gyro) pitch attitude relative to the horizon \\
 \nomenhead{Subscripts}%
 a&absolute\\
 p&probe\\
 t&tail\\
 T&true\\*
 w&wing
\end{nomenclature}

\section[Technical Approach and Procedures]{Technical Approach\\and Procedures}
The first downwash experiment was the aft-fuselage measurements.
\citeRef{Riddle81,Cochrane,Riddle87} discusses the downwash
tests, which were made at a nominal altitude of 8,000~ft, and at a series of~18 alpha
(angle-of-attack) sweeps.%
\footnote{%
The results show greater values
of downwash as the USB settings are increased.
Also, the ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$ slopes increase
from 0.75 to 1.04.%
}
\begin{Figure}%[hbtp]%
{A test
figure.}
{fig:one}%
\dropeps*{test1.epsf}%
\end{Figure}%
\begin{Figure*}%[hbtp]%
{A full-page-width figure.}{fig:two}%
\dropArt*(300,100,0){9430Phillips.2}%
\end{Figure*}%
The rake, an aerodynamically designed structure mounted to the aircraft
aft-fuselage which held 6 probes to measure the movement of air, is shown in
\figref{fig:one,fig:two}.%
\footnote{%
Also, the ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$ slopes increase
from 0.75 to 1.04.
The results show greater values
of downwash as the USB settings are increased.
}

\figRef{fig:three,fig:four} show the probes in the T-tail position.

\begin{Table}{%
comparison of finite-element thermal and structural models for space shuttle orbiter wing.%
}{tab:compare2}%
\begin{tabular}{@{}lc@{}}%
\toprule
\multicolumn{2}{@{}c@{}}{Thermal model\footnotemark[1]}\\
\cline{1-2}%
\multicolumn{1}{@{}c}{Feature}&Number\\
\colrule
JLOCs        & 232\\
E23 elements & 498\\
E25 elements &  10\\
\botrule
\end{tabular}%
\footnotetext[1]{A sample footnote for the table.}%
\end{Table}

% The following table illustrates the use of the \splittable command, which is only valid under the
% following conditions: (1) You must be within the {Table} (not {table}) environment,
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%  (2) You must be within a valid {tabular}, {alignment}, or {array} environment, and
%  (3) You must use the \toprule...\colrule syntax for the table head.
\begin{Table}{%
comparison of finite-element thermal and structural models for space shuttle orbiter wing.%
}{tab:compare1}%
\begin{tabular}{@{}lc@{}}%
\toprule
\multicolumn{2}{@{}c@{}}{Thermal model\footnotemark[1]}\\
\cline{1-2}%
\multicolumn{1}{@{}c}{Feature}&Number\\
\colrule
JLOCs        & 232\\
E23 elements & 498\\
E25 elements &  10\\
\splittable*
JLOCs        & 232\\
E23 elements & 498\\
E25 elements &  10\\
\splittable
JLOCs        & 232\\
E23 elements & 498\\
E25 elements &  10\\
\botrule
\end{tabular}%
\footnotetext[1]{A sample footnote for the table.}%
\end{Table}

\section{Results and Discussion}
The parameters of prime concern of this report are downwash ($\varepsilon$)
and wing alpha (${\alpha}_{aw}$).  Sidewash angles and local dynamic pressures
were also measured but are not addressed in this report.

\subsection{Low Tail/Aft-Fuselage Location}
\figRef{fig:four} shows downwash versus wing alpha for constant thrust (89\% fan rpm)
as the USB flap positions are varied.  The results show greater values
of downwash as the USB settings are increased from 0$^{\circ}$ to 60$^{\circ}$.
\begin{equation}%
x^2+y^2=z^2
\end{equation}%
Also, the ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$ slopes increase
from 0.75 to 1.04 as USB flap setting is increased from 0$^{\circ}$ to 60$^{\circ}$.
\begin{subeqnarray}%
x^2+y^2&=&z^2\label{eqn:two.a}\\
a^2+b^2&=&c^2\label{eqn:two.b}\\
d^2+e^2&=&f^2\label{eqn:two.c}%
\end{subeqnarray}%
As the USB flap setting increases there is a well defined difference in the
downwash behind the inboard and outboard engines.
At 60$^{\circ}$ USB flap,
\eqnref{eqn:two.a,eqn:two.b,eqn:two.c} give
the downwash behind the inboard engine as 4-5$^{\circ}$ more than that behind the
outboard engine.

% The following table illustrates side-by-side arrangement of aligned material
%
\begin{Table}{%
comparison of finite-element thermal and structural models for space shuttle orbiter wing.%
}{tab:compare}%
\tabcolsep.5\tabcolsep
\begin{tabular}{@{}lc@{}p{2\tabcolsep}@{}lc@{}}%
\toprule
\multicolumn{2}{@{}c@{}}{Thermal model}&\leavevmode
&\multicolumn{2}{@{}c@{}}{Structural model\footnotemark[1]}\\
\cline{1-2}\cline{4-5}%
\multicolumn{1}{@{}c}{Feature}&Number&&\multicolumn{1}{@{}c}{Feature}&Number\\
\colrule
JLOCs        & 2289 && JLOCs        & 232\\
K21 elements & 1696 && E23 elements & 498\\
K31 elements &   84 && E25 elements &  10\\
K41 elements &  485 && E31 elements &  19\\
R31 elements &   84 && E41 elements & 181\\
R41 elements &  568 && E44 elements &  67\\
\botrule
\end{tabular}%
\footnotetext[1]{A sample footnote for the table.}%
\end{Table}
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\begin{Figure*}[bp]%
*{Another full-page-width figure.}{fig:four}%
\dropArt(400,150,0){9430Phillips.4}%
\end{Figure*}%
Important information gained during this test includes the slope of
${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$
for the various conditions and the variation of slope with varying
thrust or USB flap settings.  \tabRef{tab:compare} shows a matrix of conditions
arranged with increasing thrust horizontally and increasing USB vertically.
It can be seen that the greatest ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$
slop is at maximum thrust (89\% fan rpm) and 60$^{\circ}$ USB flap setting, the
condition for the highest levels of wing powered lift.  At a constnt thrust \
corresponding to 89\% fan rpm, the range of ${\Delta}{\varepsilon}/{\Delta}{\alpha}$
with increasing USB flap setting is from 0.75 (0$^{\circ}$ USB flap).  For a constant
60$^{\circ}$ USB flap setting, power increases from 70\% to 89\% fan rpm cause
an increase in ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$ from 0.88 to 1.04.
The typical QSRA takeoff and landing approach conditions are high-lighted
in \tabref{tab:compare1}.
\tabRef{tab:compare} shows the realtionship between thrust and percent fan.

\begin{Figure}%[hbtp]%
{Another column-width figure.}{fig:three}%
\dropArt(200,150,0){9430Phillips.3}%
\end{Figure}%
\Figurelabel{fig:four}%
\subsection{T-Tail}
The T-tail downwash experiment consisted of three separate flights
because of the availability of only three pressure probes.  For this
reason, it was important to investigate the flight-to-flight correlation
of data using a common probe position.  \figRef{fig:five} shows correlation of
downwash for two conditions:  USB = 0$^{\circ}$, fan at 60\%, and USB = 50$^{\circ}$,
fan at 89\%.

\begin{Figure}%[hbtp]%
{Another column-width.}{fig:five}%
\dropArt(200,150,0){9430Phillips.5}%
\end{Figure}%
\figRef{fig:six} shows the spanwise T-tail downwash variation at constant 89\%
fan rpm setting with increasing USB flap setting for all 6 probe positions.
The downwash increases with USb flap setting, as in the low-tail
position \figref*{fig:four}.  However, the downwash magnitudes and the
${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$
slopes are less at the T-tail location.  Also, the distince inboard/outboard
downwash magnitude difference seen at large USB flap
settings at the low-tail position are not evident at the T-tail.

\tabRef{tab:compare1} shows a matrix of ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$
slopes for the tested conditions arranged with increasing thrust
horizontally and increasing USB flap settings vertically.
The largest ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$
varying from 0.45 to 0.78.  The corresponding low-tail
downwash slopes \tabref*{tab:compare1} are approximately 1.5 times greater than
those at the
T-tail \tabref*{tab:compare} for 89\% fan with varying USB flap setting.

\figRef{fig:seven}, a three-dimensional (3-D) plot of the downwash data obtained in both
experiments, depicts a sheet of air as experienced by the T-tail
and low-tail probes for the QSRA landing approach configuration
(50$^{o}$ USB flap, 59$^{o}$ DSF and AEO at 70\% fan rpm).
3-D data plot format shows
the relatively consistent spanwise characteristics of the
downwash fields with all engines operating.  The magnitude of the downwash
is greater at the low-tail position as is the downwash slope,
${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$, 0.85 to 0.5.

\begin{Conclusion}%
\begin{enumerate}%
\item
The downwash angle increases with increasing USB flap setting
and thrust, the two predominate wing lift increasers.  The largest
downwash occurs with maximum USB flap setting and thrust.

\item
The downwash slopes, ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$,
also increase with USB flap setting and thrust increases.  There is
also a tendency for slope increases as wing alpha increases.
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\item
The downwash slope, ${\Delta}{\varepsilon}/{\Delta}{\alpha}_{aw}$,
at the low-tail position is about 1.5 to 2 times the value of that at the
the high T-tail position.  This means that the low-tail position provides
less stability than the high T-tail position.  This would increase the need
for a stability augmentation system (SAS) for a low-tail configuration.
The trim changes would also be higher at the low-tail position increasing
the need for a variable incidence horizontal stabilizer at the low-tail
position.  Automatic trim may be required as USB flap setting and
thrust are increased on a low-tail configuration.
\end{enumerate}%
\end{Conclusion}%

\appendix*
\section{Downwash characteristics}
Important information gained during this test includes the slope of
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